

Southern California Earthquake Center
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Annual Project Summary

Selected highlights of SCEC's integrative and outreach activities for the past year are summarized in the following sections. The activities represent, to a large extent, partnerships between SCEC and the U.S. Geological Survey.

1. Continuation and Completion of Collaborative Activities

SCIGN. The Southern California Integrated GPS Network (SCIGN), under construction since 1995, has now been completed with 254 continuously operating GPS receivers now in place throughout southern California and northern Baja California. SCIGN stations are weighted toward the greater Los Angeles basin where the network is focused on identifying structures, including blind faults that may be responding to tectonic convergence across the region. SCIGN includes three processing centers – at Scripps, JPL, and the USGS – with funding from NSF, NASA, and the USGS. Current estimates from JPL and Scripps indicate that the agreement in horizontal motions between the two processing centers is 1.68 ± 2.50 mm/yr north and 1.20 ± 2.28 mm/yr west. In addition to the Los Angeles basin, SCIGN continues its study of the Eastern Mojave Shear Zone, site of the Landers and Hector Mine earthquakes – with a focus on post-earthquake crustal deformation.

Also close to completion and part of SCIGN, is the new 600 meter long baseline laser strainmeter installation along the Glendale Freeway between the 134 and 210 freeways. SCEC is grateful to the California Department of Transportation (Caltrans) for making this excellent site available. The strainmeter is located within the greater Los Angeles basin GPS network in order to provide an independent check on any short-term strain transients that may be detected by one or more GPS receivers. It is anchored at one end in weathered granitic rock, and at the other end in decomposed granite, and oriented roughly in the direction of maximum regional convergence. We anticipate that the instrument will be operational by mid-year 2002.

In order to acknowledge the completion of SCIGN, SCEC held an unveiling event on July 6, 2002. The event was designed to both commemorate the work of the SCIGN team in creating the array and introduce and explain the importance of the project to the public.

Phase III Report and Amplification Map. The SCEC Phase III Working Group completed their work on determining the extent to which probabilistic seismic hazard analysis can be improved by accounting for site effects with the publication of a series of reports in a December 2000 special issue of the Bulletin of the Seismological Society of America, and publication of an earthquake ground motion amplification map for southern California later in 2001.

The Phase III Report defined the site effect, vis-à-vis probabilistic seismic hazard analysis, as the response, relative to an attenuation relationship, averaged over all damaging earthquakes in the region. Efforts were made to identify any attributes that predispose a site to greater or lower levels of shaking. The most detailed maps of Quaternary geology were not found to be helpful in this regard – either they are overly detailed in terms of distinguishing different amplification factors, or current southern California strong-motion observations are inadequate to reveal their superiority. However, a map based on the average shear-wave velocity in the upper 30 meters was found to delineate significantly different amplification factors. A correlation of amplification with basin depth also was found to be significant, implying up to a factor of two difference between the shallowest and deepest parts of the Los Angeles basin. Questions remain as to whether basin depth is a proxy for some other site attribute.

In spite of these important site effects, the standard deviation of an attenuation relationship (the prediction error) will not be significantly reduced by making such

corrections. That is, given the influence of basin-edge-induced waves, subsurface focusing, and general scattering, any model that attempts to predict ground motion with only a few parameters will have a substantial intrinsic variability.

Following publication of the results of Phase III, SCEC together with the USGS and the California Division of Mines and Geology produced a full-color map and poster of the earthquake ground-motion amplification in southern California. The two most important factors influencing the level of earthquake ground motion at a site are the magnitude and distance of the earthquake. This new map shows the influence of a third important factor, the site effect, by which local geologic and structural conditions can amplify or de-amplify the ground motion. Specifically, the map combines the shear-wave velocity in the upper 30 meters with the basin depth as determined by the 2.5 km/sec shear-wave velocity iso-surface in the SCEC 3D velocity model for southern California, to generate amplifications based on the attenuation relationship of Field (2000) for 1.0-second response spectral acceleration. Posters are available from the Southern California Earthquake Center (www.scec.org).

Highlights Volume. SCEC is proceeding with production of a combination hard copy and web-based publication chronicling the center's research and outreach highlights over the past 11 years. The publication will consist principally of graphics with extended figure captions or brief summaries relating to each graphic or set of graphics. The audience is anticipated to range from researchers and agency representatives to the scientifically-informed general public. We anticipate completion of the document by mid-year 2002.

RELM. Following the series of collaborative studies and reports referred to as "SCEC Phases I, II, and III", we are proceeding with Phase IV (RELM – Regional Earthquake Likelihood Models), an update of Phase II (source characterization). The SCEC RELM Working Group is led by Ned Field of the USGS (see also www.relm.org).

In contrast to previous efforts, the goal of RELM is not to develop a single "consensus source model", but rather to develop a variety of viable models based on various geophysical constraints (e.g., seismicity, geology, geodesy, stress transfer, and/or foreshock/aftershock statistics). There are several reasons for this approach, one of which is to determine the uncertainty of hazard levels given alternative models. Another is to evaluate which models are exportable to other regions where the options are fewer.

The effort includes the compilation of an earthquake catalog, a fault-parameter database, and geodetic observations (all to be web accessible). In addition to the RELM Working Group, some of the data gathering efforts are being broadened and subsumed by other SCEC focus groups.

Part of the goal of RELM is to evaluate the hazard implications of each earthquake-forecast model. This was done in the past by making hard-wired modifications to existing Fortran PSHA codes. One problem with this approach is that the customized code is useless for doing anything else. A second problem is that some of the models under development in RELM (e.g., those based on short-term foreshock/aftershock statistics) do not fit within the framework of existing PSHA codes, so a major rewrite would be required for their implementation. In addition, no existing PSHA code has all the following desired attributes:

- open source
- well documented
- formally reviewed
- object oriented (ideal for PSHA)
- easily parallelizable
- network savvy, secure, and robust with errors
- web-based applications with a graphical user interface

Therefore, as part of the RELM effort, we have begun the development of new, Java-based PSHA code that will enable all of the above.

The most critical and challenging part of developing object-oriented code is designing the overall framework (defining all object classes and their relationships). Only when this design phase is done, and all associated documentation developed, does the actual programming begin. With SCEC funding we have established the overall framework for the PSHA code (preprint of *SRL* article available upon request), and have begun implementing this framework in Java. Documentation of the more than 60 Java classes is available at www.scec.org/psha/docs.

In addition to being capable of implementing all RELM models currently under development, the code has also been designed to implement all viable intensity-measure relationships (attenuation relationships) including those based on directivity and basin effects. Perhaps most importantly, however, is that the code will be capable of handling several anticipated future developments without rewriting any code. Examples include the implementation of new and different “Intensity

Measures” (functionals of ground motion found to correlate with damage) and vector-valued PSHA, both of which are being developed by the Pacific Earthquake Engineering Center (PEER) and will be a future topic of SCEC-PEER interaction. In addition, the code has been designed so that ground-motion estimates can be based on suites of 3D synthetic seismograms rather than on empirical “attenuation” relationships (i.e., when mature models from the SCEC Ground Motions Focus Group will be available). In summary, much effort has gone into designing an overall seismic-hazard analysis framework that will accommodate ongoing developments in virtually all components of SCEC and other organizations such as PEER.

The following additional information can be obtained at the RELM web site:

- Mission and Goals
- Background & Overview
- Models Under Development
- Supporting Efforts and Databases
- Participants and Email Groups
- SCEC IT Collaboration
- Tutorial Materials
- Schedule and Workshop Reports

Active Faults in the Los Angeles Metropolitan Region. An evaluation of earthquake fault sources in the Los Angeles Basin and nearby urbanized areas based on fault geology has been prepared by the SCEC Working Group on Earthquake Geology (J. Dolan, E. Gath, L. Grant, M. Legg, S. Lindvall, K. Mueller, M. Oskin, D. Ponti, C. Rubin, T. Rockwell, J. Shaw, J. Treiman, C. Walls, and R. Yeats). Yeats acted as compiler.

The objective of the evaluation was to determine the location of active faults and their slip rates and earthquake recurrence intervals. This includes the location and dip of those faults reaching the surface and blind faults that are expressed at the surface by folding or elevated topography.

Slip rate determinations are based on several timescales. The tectonic regime of the Miocene was generally extensional, and the north-south contractional regime came into being in the early Pliocene. The longest timescale for slip-rate estimates, then, is the time of imposition of the north-south contractional regime, the past 5×10^6 years. Another timescale is the early and middle Quaternary ($\sim 2 \times 10^6$ years), the time of deposition of the upper Pico member of the Fernando Formation plus

the shallow-marine to nonmarine San Pedro Formation. Information for the first two timescales is derived from the subsurface using oil-well and water-well logs, multichannel seismic profiles, and surface geology. A third timescale is the late Quaternary (10^2 - 10^5 years), information for which is obtained through trench excavations, boreholes, and high-resolution seismic profiles and ground-penetrating radar augmented by the 232-year-long record of historical seismicity in the Los Angeles area. The shortest timescale (10 yrs) is that afforded by repeated GPS observations.

The late Quaternary rate is the most representative long-term rate in forecasting future behavior because it provides a geologically- and statistically-significant averaging time but is unlikely to be contaminated by Pliocene and early Pleistocene geologic processes no longer active today. The late Quaternary rate may be different from the rate based on GPS observations. For example, the GPS rate across the Eastern California Shear Zone is considerably higher than the late Quaternary geologic estimates. In California, similar differences between GPS and geology may occur on the Garlock fault. In this instances, the GPS rate may not be steady state but may represent a short-term strain transient.

This report (available from the Southern California Earthquake Center) summarizes the evidence for slip rates across faults of the Los Angeles metropolitan region and calculates the north-south component of shortening to compare with the convergence rates of about 4.4 mm/yr between downtown Los Angeles and the San Gabriel Mountains based on GPS data.

2. Communication, Education, and Outreach Activities

The transfer of SCEC's research results to other communities as an essential component of its mission. The SCEC Communication, Education and Outreach (CEO) program has established itself as a valuable resource for southern California.

SCEC CEO long-term goals are:

- To promote earthquake understanding and general science literacy at all educational levels.
- To reduce economic losses and save lives by increasing earthquake awareness and improving hazard and risk assessments

SCEC's CEO program has pursued four main objectives:

- Build upon student's and the public's intrinsic interest in the natural environment,
- Utilize the scientific and educational expertise of SCEC in outreach and knowledge transfer,
- Expand access to earthquake information via the Internet and other media, and
- Foster a greater public understanding of earthquake risk.

Following are highlights of SCEC's 2001 CEO program.

Wallace Creek Interpretive Trail. In partnership with The Bureau of Land Management (BLM), SCEC designed an interpretive trail along a particularly spectacular and accessible 2 km long stretch of the San Andreas Fault near Wallace Creek, located on the Carrizo Plain – a 3-4 hour drive north of Los Angeles. The trail opened in January 2001. The area is replete with the classic landforms produced by strike-slip faults: shutter ridges, sag ponds, simple offset stream channels, mole tracks and scarps. SCEC created the infrastructure and interpretive materials (durable signage, brochure content, and a website with additional information and directions to the trail). BLM has agreed to maintain the site and print the brochure into the foreseeable future.

www.scec.org/instanet/00news/news000913.html

www.scec.org/wallacecreek

SCEC Museum Partnerships. SCEC has established a partnership with the Riverside County Children's Museum, CUREE-Caltech Woodframe Project (for which SCEC has managed the education and outreach activities), and UC Riverside to create an educational, family-oriented exhibit on earthquakes ("ShakeZone") in their region. The mission of the exhibit is to reach the local community, particularly elementary and secondary school children, with positive messages about studying the Earth and preparing for earthquakes. The exhibit will present information about science, engineering, safety and mitigation. A shake table, an interactive computer display, and wall displays will teach the visitors about the tools and techniques of earth scientists, engineers and emergency services personnel.

(www.scec.org/instanet/00news/news000619.html)

2001 Summer Internship Program. To provide hands-on experiences in the earth sciences, provide insights into career opportunities, and interest underrepresented undergraduate students in Earth science-related careers, SCEC has funded 72 students to date (including 39 women and 16 minority students) to work alongside 50 SCEC scientists over the past 7 years. Although the program was not funded last year by SCEC directly due to budget constraints, three undergraduate students participated in a modified program based on funding from research mentors. To begin the summer, the interns attended a Communication Workshop held jointly with interns from the Pacific Earthquake Engineering Research Center (PEER). Students participated in a two-part field trip led by Dr. James Dolan (USC) and Dr. Doug Yule (CSUN). Finally, students present posters at the SCEC annual meeting. (www.scec.org/internships)

Seismic Sleuths Revision. SCEC has revised the AGU/FEMA Seismic *Sleuths* middle school earthquake curriculum to reflect advances in science and technology since the last update in 1995. The objectives are to promote and improve natural hazard education for students; to foster preparedness for natural hazards through empowerment and encouraging personal responsibility; to provide an updated and redesigned learning tool that can be easily integrated into a curriculum based on national standards; and to provide constant updates in science content, pedagogy, and resource information through an interactive website. Each unit has been streamlined and can stand alone in order to be used in a variety of environments. In addition, a television special (*Earthquakes: Seismic Sleuths*) based on the series has been created, made possible by funding from the California Earthquake Authority, the Institute for Business and Home Safety, and SCEC. The hour-long video was broadcast on “Assignment Discovery” in spring, 2001. The video can be used by teachers as an excellent advance organizer, or viewed by interested citizens who want to learn more about earthquakes, the destruction they can cause, the scientists and engineers who study them, and what they can do to prepare.

www.scec.org/instanet/00news/news000808.html

www.scec.org/instanet/01news/news010330.html

Electronic Encyclopedia of Earthquakes. This collaborative project between SCEC, CUREE and IRIS is synthesizing a large and varied amount of data and information, and providing broad access via the Internet in the context of the Digital Library for Earth System Education (DLESE). The subject matter features earth science as well as principles of engineering, physics and mathematics. The collection is primarily aimed at supporting high-quality high school and undergraduate education by providing educators and students with the tools and resources for instruction and research. The framework for the Encyclopedia has been developed and the content collection process is on-going.

www.scec.org/ecube

SCEC Webservice and SCEC InstaNET News. SCEC's webservice presents the research of SCEC scientists, provides links to SCEC institutions, research facilities, and databases, and serves as a resource for earthquake information, educational products, and links to other earthquake organizations. Last year SCEC introduced the SCEC InstaNET News to provide a source of information in all matters relevant to the SCEC community – to disseminate news, announcements, earthquake information, and in-depth coverage of earthquake research, in a timely manner via the World Wide Web. Since its inception in March 2000, over 1300 people have subscribed to e-mailed news "bytes" which announce new articles.

<http://www.scec.org/instanet>

<http://www.scec.org>

SCEC Publication distribution. Copies of SCEC's field trip guides, technical reports (Phase I & II reprints, Liquefaction Mitigation Guidelines report, etc.), and *Putting Down Roots in Earthquake Country* general public brochure continue to be widely distributed at workshops, earthquake preparedness fairs, and through the SCEC website. New for summer 2001 is the availability of the *SCEC Phase III Amplification* poster. The two most important factors influencing the level of earthquake ground motion at a site are the magnitude and distance of the

earthquake. A new wall poster (30" x 36", \$10) shows the influence of a third important factor, the site effect, where conditions at a particular location can increase (amplify) or decrease the level of shaking that is otherwise expected for a given magnitude and distance.

<http://www.scec.org/outreach/products/index.html>

EqIP. SCEC Outreach participates in the EqIP (Earthquake Information Providers) group which connects information specialists from most earthquake-related organizations. EqIP's mission is to facilitate and improve access to earthquake information through collaboration, minimize duplication of effort by sharing information through individual personal contact, joint activities and projects, group annual meetings and biennial forums, and electronic communication. SCEC managed the development, of EqIP's website which provides a database of descriptions of over 250 organizations with links to their websites. In 2001, Mark Benthien developed an online survey of EqIP members to assess EqIPs success.

<http://www.eqnet.org>

www.eqnet.org

HAZUS. Over the past year SCEC has been moving toward greater use and understanding of Hazards US (HAZUS), FEMA's earthquake loss estimation software program. SCEC CEO is coordinating the development and activities of



the Southern California HAZUS Users Group (SoCalHUG). with FEMA, the USGS, and OES. SoCalHUG is modeled on the existing San Francisco Bay Area HAZUS User's Group (BAHUG). It brings together current and potential HAZUS users from industry, government, universities, and other organizations to (a) train GIS professionals in HAZUS earthquake loss estimation software, (b) improve earthquake databases and inventories, and (c) develop and exercise emergency management protocol. SCEC is also considering how it can improve the data and models which HAZUS uses in

its calculations. On April 26th, a "Kick-off Meeting" of SoCalHUG was held, and in late July a HAZUS training was held at California State University Fullerton for 23 Geographic Information System professionals employed by local governments, utilities, universities, and corporations. Funding for the training was provided by FEMA in response to a proposal by the SCEC and the OES.

(<http://www.hazus.org>, www.scec.org/instanet/00news/news001206b.html, and www.scec.org/instanet/01news/news010803.html)

International Conference on Disaster Management. This conference was held August 6-10, 2001 in Orlando, Florida. This conference was aimed at all emergency responders and will cover terrorism, hazmat, earthquakes, tornadoes, wildfire, flooding, volcanoes and hurricanes. Sponsors and Participants included: American Red Cross, FEMA, FBI, National Emergency Management Association, Institute on Business and Home Safety, National Domestic Preparedness Office and others. SCEC CEO organized three of the sessions on earthquakes: "Identifying the Earthquake Hazard", and "Being Prepared for Earthquakes." The first two sessions featured speakers from four regions of the country: Southern California, Pacific Northwest, Mid America, and the Northeast. The third session was titled "Using HAZUS for Earthquake Risk Assessment." The sessions were conducted on Monday, August 6. Tom Jordan, Director Designate of SCEC, spoke about earthquake research in the 21st century during the general session on Tuesday, August 7. (www.scec.org/instanet/01news/news010702c.html)



AEG workshop on seismic hazard probabilities. This one-day short course on May 18 at USC was designed to provide greater understanding of probabilistic seismic hazard analysis (PSHA) and its applications. The course provided in-depth discussion of this specialized topic, in clear terms, with an emphasis on both fundamental and more advanced concepts. The course was jointly sponsored by the

Association of Engineering Geologists (AEG), Southern California Section, and SCEC, and was intended for practicing earthquake professionals. In this course, Dr. Rob Sewell keeps unfamiliar mathematics to a minimum, and describes elements of probabilistic analysis in a transparent way, using familiar graphical illustrations of key concepts. The PSHA principles are explained and demonstrated with real-world examples that involve the application of PSHA software, such as the widely used program FRISKSP.